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conforming frame that holds the block in place while allowing the block a small amount of "wobble room" within the frame. This solution allows the receptacle to assist in aligning the probe within the receptacle. However, the use of a single floating probe block is problematic when probing two or more
5 receptacles on the DUT (e.g., charger plugs and audio plugs).

Due to manufacturing limitations, at least some error relative to specification typically exists in the precision of the location of the DUT receptacles relative to the DUT case and also relative to the other DUT receptacles on the DUT. Thus, over hundreds and thousands of a give DUT
10 to be tested, the probe block must be designed to take into account the receptacle location tolerances such that the probes of the probe block can reliably make electrical contact with each DUT receptacle to be probed.

A single probe block cannot account for these differences. The single probe block aligns to one of the receptacle features on the DUT, while
15 forcing the other probes into their respective receptacles. This force is a major source of wear on both the DUT being probed and the probe block, and also can cause connector failure on the DUT.

Summary Of The Invention

The present invention is a multiple two-axis floating split probe block assembly for testing an electrical device. The invention uniquely provides a floating probe block assembly with independent floating probe blocks for each probe to be inserted into the DUT. Each independent floating probe block is mounted in a single common probe block assembly frame. Each
20 independent floating probe block therefore floats independently of the other probe blocks in the frame to allow it to directly align with its mating receptacle on the DUT. The unique multiple-independent float capability of the invention allows reduction in wear on the probe block and DUT receptacle, and also reduces the insertion force required to probe the DUT.
25 This allows for smaller insertion probing actuators, thereby saving space and cost while minimizing wear to the DUT. In addition, insertion probing of multiple receptacles may be performed with one actuating action, thereby reducing test time.
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The present invention is ideal for use in a test fixture during manufacturing- or final-level device under test (DUT) in which the DUT requires some insertion probing of multiple receptacles whose location on the DUT varies with respect to each other. The invention compensates for DUT-to-DUT and fixture-to-fixture differences over thousands of DUTs, in a novel manner that is more reliable than other methods currently used.

Brief Description Of The Drawings

A more complete appreciation of this invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or similar components, wherein:

FIG. 1 is an exploded isometric view of a floating probe block assembly implemented in accordance with the invention;

FIG. 2 is an isometric view of an assembled floating probe block assembly of FIG. 1;

FIG. 3 is a detailed isometric view of one of the probe blocks from the floating probe block assembly of FIG. 1;

FIG. 4 is an exploded front view of the assembly of FIG. 1;

FIG. 5 is a front view of the assembled floating probe block of FIG. 1;

FIG. 6 is a flowchart of an insertion probing method; and

FIG. 7 is a flowchart of a floating probe block assembly method.

Detailed Description

Turning now to the drawings, FIGS. 1-5 illustrate a preferred embodiment of a multiple two-axis floating split probe block assembly 10 for testing an electrical device. In this embodiment, the probe block assembly 10 includes a split probe block 40 (i.e., two independent probe blocks 50, 60) mounted in a single common probe block frame 20.

In the illustrative embodiment, the probe block assembly 10 is designed to probe the system connector and audio jack of a cellular phone (not shown). Accordingly, in the illustrative embodiment, the probe block assembly 10 comprises two independent probe blocks, including a system connector probe block 50 for probing a system connector and an audio jack probe block 60 for probing an audio jack on the cellular phone.

In the illustrative embodiment, the system connector of the cellular phone (not shown) comprises an array of electrical contact pads and a two-prong electrical socket. Accordingly, the system connector probe block 50 of the probe block assembly 10 includes a mating array of spring-loaded probes 52 for contacting the electrical contact pads of the cellular phone and an electrical two-prong plug 53a, 53b for insertion into the cellular phone electrical two-prong socket when the system connector probe block 50 is used to probe the cellular phone system connector.

Also in the illustrative embodiment, the audio jack of the cellular phone comprises a single audio jack (not shown). Accordingly, the audio jack probe block 60 of the probe block assembly 10 includes a mating audio plug 62 for insertion in the cellular phone audio jack.

FIG. 3 shows the system connector probe block 50 (which probes the system connector of a DUT) in greater detail. As illustrated in FIG. 3, the system connector probe block 50 comprises a probe block body 51, an array of system connector probes 52, a power plug comprising a pair of prongs 53a, 53b, and four self-centering spring receptacles 54a, 54b, 54c, 54d (two on top and two on bottom). In the preferred embodiment, the system connector probe block body 51 is configured as a solid block, formed for example from material such as aluminum or steel. The probes 52, 53a, 53b are electrically connected to wires or traces which are connectable to test and/or measurement circuitry (not shown).

The audio jack probe block 60 is constructed similarly, and is therefore not shown in greater detail (wherein the system connector probes 52 and power plug 53a, 53b and associated circuitry are replaced with an appropriate audio jack probe 62 and related circuitry (not shown)).

Optionally, to assist with self-centering, in the preferred embodiment each independent probe block 50, 60 includes one or more self-centering spring receptacles 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h, each for holding a coil spring 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h of longitudinal length L_{SPR} and having a coil diameter of D_{COIL} . In the illustrative embodiment, each independent probe block 50, 60 includes two pairs (54a/b, 54c/d, and 54e/f, 54g/h, respectively) of self-centering spring receptacles. Each receptacle 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h in a given pair of receptacles is

located coaxially to the other receptacle in the pair and each opens onto opposing sides of its respective probe block 50, 60. In the preferred embodiment, the coaxial axis of each receptacle pair 54a/b, 54c/d, and 54e/f, 54g/h is perpendicular to the probing direction (indicated by arrow A in FIG. 2).

Each spring receptacle 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h is preferably configured as a cylindrical bore with circular cross-section of constant diameter. Each spring receptacle 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h has one opening to a side of the probe block body and a wall opposite the opening positioned within the probe block 50, 60 to support the spring. In addition, the receptacle opening is preferably countersunk 55a, 55b, 55c, 55d, 55e, 55f, 55g, 55h, for reasons discussed hereinafter. The cross-sectional diameter D_{REC} of the cylindrical spring receptacle 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h is a known precise amount greater than the cross-sectional diameter D_{COIL} of the self-centering spring coil 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h that is designed to fit into it, and is sufficient to allow a small amount of "wiggle room" without allowing significant shear (side-to-side) deflection. The length L_{REC} of the spring receptacle 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h is a known precise amount less than the longitudinal length L_{SPR} of the coil spring 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h when the coil spring is in a non-deformed state.

A coil spring 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h characterized by a longitudinal length L_{SPR} and cross-sectional diameter of D_{COIL} as just described is mounted in each receptacle 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h of the probe blocks 50, 60.

It is to be understood that the self-centering features just described are optional only for purposes of assisting in self-centering the independent probe blocks within the frame 20. However, such self-centering is not a necessary feature of the invention itself.

In the illustrative embodiment, the probe block frame 20 is substantially conforming to the outer shape (less the probes 52, 53a, 53b, 62 and certain other protruding features) of the composite independent probe blocks 50, 60 when seated side by side in the frame 20, and includes apertures 27 to allow the probes 52, 53a, 53b, 62 and other protruding

features of the probe blocks 50, 60 to protrude outside the frame 20 when the probe blocks 50, 60 are seated within the probe block frame 20. The inner dimensions of the probe block frame 20 substantially match those of the outer dimensions of the composite side-by-side independent probe blocks 50, 60 plus a small predetermined amount sufficient to allow a certain amount of "wiggle room" but insufficient to allow significant displacement of the independent probe blocks 50, 60 from their average position in the frame. This allows the probe blocks 50, 60 to independently "float" within the probe block frame 20.

It will be appreciated that other frame configurations for floating the multiple independent probe blocks 50, 60 within a single frame 20 may be used and the illustrative embodiment is provided for purposes of illustration only and not by way of limitation.

In the illustrative embodiment, the probe block frame 20 includes a front frame arm 23a, a rear frame arm 23b, a frame base 22, and a frame cover 21. The front frame arm 23a is substantially U-shaped, having two vertical members 25a, 26a separated by a horizontal base 24a. Formed integral to the horizontal base 24a is a frame attachment member 29 configured to mate with an arm attachment base 28 that is attachable to a robotic actuator (not shown).

The rear frame arm 23b is formed substantially identical to the front frame member 23a. The horizontal bases 24a, 24b of the front frame arm 23a and rear frame arm 23b are respectively attached on top of and along the respective front and rear edges of the frame base 22, such that the front frame arm 23a and rear frame arm 23b are aligned front-to-rear and separated by a distance determined by the width of the frame base 22. The frame cover 21 attaches to the top of the vertical members 25a, 26a, 25b, 26b of the front frame arm 23a and rear frame arm 23b.

When the probe block frame 20 is assembled, it forms an inner cavity with one or more apertures 27 through which probes 52, 53a, 53b, 62 and other protruding features of the independent probe blocks 50, 60 may extend outside the frame 20 when the independent probe blocks 50, 60 are seated side by side within the probe block frame 20. The inner cavity substantially conforms to the outer shape and dimensions of the composite probe blocks

50, 60, less any protrusions that extend through the apertures 27 of the probe block frame 20. The dimensions of the inner cavity are designed to be a predetermined small amount (e.g., several millimeters, sufficient to allow a small amount of "wobble room") greater than the respective composite
5 matching dimensions of the independent probe blocks 50, 60 when the probe blocks 50, 60 are mounted in position within the frame 20 (e.g., in the illustrative embodiment, side-to-side). This allows the independent probe blocks 50, 60 to "float" independently of one another within the probe block frame 20.

10 To assemble the probe block assembly 10, the frame cover 21 is removed from the probe block frame 20. Optionally, self-centering springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h are seated within the self-centering spring receptacles 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h of the independent
15 probe blocks 50, 60, and the independent probe blocks 50, 60 are inserted into their respective designated positions within the inner cavity of the probe block frame 20 through the uncovered top of the frame. In the illustrative embodiment, the system connector probe block 50 and audio jack probe block 60 are seated side-by-side with their probes 52, 53a, 53b, 62
20 extending in the same direction parallel to the axis of probing (see arrow A in FIG. 3). Preferably, the probe block frame 20 includes countersunk spring receptacles 70a, 70b, 70c, 70d, 70e, 70f, 70g, 70h that match up with the locations of the self-centering springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h of the independent probe blocks 50, 60 when the independent probe blocks are seated in position within the frame 20. Accordingly, in the illustrative
25 embodiment, when inserting the independent probe blocks into the open frame, the protruding portions of the springs 42b, 42d, 42f, 42h on the bottoms of the independent probe blocks are carefully inserted into their respective countersunk spring receptacles 70b, 70d, 70f, 70h of the frame base 22. The cover 21 is then aligned over the top of the frame 20, carefully
30 aligning the respective countersunk spring receptacles 70a, 70c, 70e, 70g, of the frame cover 21 over the protruding portions of the springs 42a, 42c, 42e, 42g on the tops of the independent probe blocks 50, 60, and the cover 21 is attached (for example, via screws).

During use, the arm attachment base 28 of the probe block frame is fixedly attached to a linear actuator (pneumatic or otherwise, such as an actuating robotic arm, not shown) that moves in the probing direction (also referred to as "axis of probing") as indicated by arrow A. The actuator
5 operates to move the frame 20 with independently floating probe blocks 50, 60 therein to engage the probe(s) 52, 53a, 53b, 62 of the respective probe blocks 50, 60 with their respective mating receptacles on the DUT (not shown). When engaged, the alignment features in each independent probe block 50, 60 independently aligns to the mating features in the DUT and
10 inserts to make electrical contact.

As described previously, in the preferred embodiment, each independent probe block 50, 60 utilizes self-centering springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h to allow the probe block to independently self-center. To this end, when the independent probe blocks 50, 60 are seated in the
15 assembled probe block frame 20 with the cover 21 attached, as shown in FIGS. 2 and 5, the self-centering springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h operate to independently self-center their respective independent probe blocks 50, 60 in both the vertical and horizontal directions. The springs are mounted in the spring receptacles 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h
20 positioned in pairs on opposite sides of the independent probe blocks 50, 60 such that the spring pairs are directly coaxial with one another. The spring receptacles 54a, 54b, 54c, 54d, 54e, 54f, 54g, 54h are preferably identical, and the springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h are preferably identical in size, shape, composition, and spring characteristics (e.g., spring
25 constant). Accordingly, each independent probe block 50, 60 achieves a point of static equilibrium (or self-centering relative to the vertical plane) when the springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h are each compressed by the same amount.

To achieve self-centering relative to the horizontal plane, the
30 countersinking of the hole openings 55a, 55b, 55c, 55d, 55e, 55f, 55g, 55h in each independent probe block 50, 60 allows the springs 42a, 42b, 42c, 42d, 42e, 42f, 42g, 42h to deflect side to side in the shear direction. Thus, the static equilibrium point is achieved when all springs in the independent probe

blocks 50, 60 are vertically linear and horizontally undeformed. This centers each independent probe block 50, 60 in the horizontal direction.

During insertion probing (FIG. 6), the entire probe block assembly 10 is positioned in front of the fixtured DUT in such a position that each
5 independent probe block 50, 60 is aligned (step 101, 102) to the respective feature to be probed on the DUT (e.g., audio jack, system connector, charge jack, etc.). In a single actuation motion (step 103), the probes 52, 53a/b, 62 are inserted and engaged with corresponding DUT receptacles. When the probe block 40 is disengaged, it allows easy loading and unloading of the
10 DUT into the fixture. When it is engaged, it has full probing/insertion into the DUT.

The present invention offers several advantages over the prior art. First, as discussed in detail above, the probe block assembly 10 of the invention provides an independent float for each connector probe that is
15 inserted into the DUT. This independent float solves the problem of DUT-to-DUT variances in DUT receptacle location. Tight tolerances are required to probe small test points on the DUT, but poor tolerances in the location of these test points relative to the outside case of the DUT and to each other make robust probing difficult. Independently floating the multiple connector
20 probes allows the multiple probes to independently self align to the position of the mating receptacles on the DUT without regard to the position of the other receptacles on the DUT. Accordingly, DUT-to-DUT variances in the locations of the connectors to be probed are no longer a concern.

Secondly, the illustrative side-by-side arrangement of the independent
25 probe blocks within a single assembly allows insertion probing of all DUT connectors that lie on the same side of the DUT to be probed via a single actuation motion of the probe assembly actuator. This reduces test setup time, testing time, and tester complexity.

Additionally, providing independent float of each of the connector
30 plugs reduces the amount of insertion force required to probe the DUT, and therefore increases reliability while reducing wear.

Finally, the independent float of independent probe blocks may be combined with independent self-centering of the independent probe blocks

to assist in quickly and inexpensively aligning each independent probe block with its mating feature on the DUT.

Although this preferred embodiment of the present invention has been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

For example, it should be understood that the although the illustrative embodiment describes a probe block assembly 10 with only two independent probe blocks, the invention extends to any probe block assembly with multiple (i.e., two or more) independent probe blocks. In addition, the positioning of the independent probe blocks within the frame may be mounted in various alternative configurations to the side-by-side configuration of the illustrative embodiment (e.g., top-to-bottom). Additionally, although the invention has been described in the application of insertion assembly, the probe blocks in the probe block assembly may alternatively include receptacles that are probed by the DUT when the probe block assembly is engaged with the DUT. It is to be understood throughout the disclosure that anywhere reference to the probe block assembly includes a "probe" relative to a mating "receptacle" on a DUT, the position of the "probe" and "receptacle" may alternatively be interchanged such that the probe block assembly provides a mating "receptacle" for a mating "probe" on the DUT. Accordingly, the invention extends to such probe/receptacle interchanges. It is also possible that other benefits or uses of the currently disclosed invention will become apparent over time.